

fall was 53 inches, and the winter's total exceeded 10 feet. All highways were absolutely impassable for automobiles from the first week in January to the last week in March.

Through the kindness of several of the station officials, the writer has secured comparative snowfall data for a number of the more Northern States. At Albany and New York the snowiest winter occurred more than 30 years ago, but there have been only six winters with more snow than fell in that of 1922-23. The records at New Haven extend back to 1873, and the data have been averaged by 10-year periods, beginning with the earliest records, with the following results: 48.8, 40.8, 42.3, 39, and 35.6 inches. A gradual falling off is indicated at New Haven, yet the heaviest of record occurred as late as the winter of 1915-16, and last winter the total was 19 inches above the normal.

Another old record is that of Boston, beginning with 1871. Our friends who believe the climate is changing might find comfort in learning that the greatest seasonal snowfall of record at Boston (96.4 inches) was in 1873-74, but the winter with the least snow (5.3 inches) was only two years later. By 10-year periods, commencing with 1873, the averages are: 44.1, 47, 44.5, 39.8, and 47.6 inches. The last is the greatest. Just as was the case at Albany and New York, the snowfall of the winter 1922-23 has been exceeded but six times. The total was 24.3 inches above the normal.

At Portland, Me., the greatest total snowfall for a

winter (125.5 inches) occurred in 1886-87, but last winter, with but one-half inch less, was next in amount. The decade averages at Portland are: 74.8, 77, 72, and 75.9 inches. The heaviest snowfall of record at Northfield, Vt. (193 inches) occurred during the winter of 1887-88, but the second greatest was in a recent winter, that of 1921-22, and the fourth greatest just two years earlier. Rochester, N. Y., is an especially snowy place. The greatest fall (142 inches) was in 1900-1901; the least, in 1918-19. The averages by decades (10-year periods) at this station are: 76.1, 99.3, 71, and 78.3 inches. Buffalo had the greatest total in 1909-10 and the least 20 years earlier. In the West we find that Cheyenne's winter of least snow was back in 1885-86 and the greatest some 19 years later. The greatest total of record at Salt Lake City occurred in the winter of 1916-17, and the second, third, and fourth since then. The following figures are given by way of comparison, the dates indicating the winter of greatest snowfall: Columbus, 1909-10; Detroit, 1899-1900; Helena, 1880-81; Lincoln, 1914-15; Spokane, 1889-90.

There is evidence enough to permit persons in certain localities to really believe that the days of heavy snowfall are past, but viewing the subject in a broad way we are led to conclude that there will undoubtedly be heavy snows in the years to come just as there have been in the past, and it is probable that present records will be exceeded at many places.

THE NATIONAL ELIMINATION BALLOON RACE FROM INDIANAPOLIS, IND., JULY 4, 1923.

By L. T. SAMUELS, Meteorologist.

[Weather Bureau, Washington, D. C., August 20, 1923.]

The three contestants covering the greatest distance from the starting point in this event are chosen to represent the United States in the International Balloon Race—a sporting event in which contestants compete for a cup donated in 1906 by the late James Gordon Bennett. Although, as has been stated, this is a sporting event, there is extensive opportunity during these races for obtaining information of value to the science of meteorology. For this reason it has been customary for the Weather Bureau, in events of this sort, to contribute from its knowledge of wind conditions both on the surface and in the free air such information as may be of value to contestants.

Mr. C. G. Andrus was again the Weather Bureau observer in the race acting as aid to Mr. R. H. Upson, while the writer was assigned to Indianapolis for the purpose of giving the contestants first-hand information obtained from special pilot-balloon observations made at Indianapolis and at a number of surrounding Weather Bureau and Army aerological stations. In addition to the arrangements made for having this detailed information directly available at the starting place, the district forecaster at Chicago forwarded special advices for the balloonists.

Arrangements were also made to have telegraphed to Indianapolis on July 2, 3, and 4 the computed free-air pressures from a number of stations east of the Rocky Mountains. This made possible the drawing of charts depicting the atmospheric pressure at 1,000 and 2,000 meters above sea level.¹ This phase of Weather Bureau work is of recent development and it may be said that

this was the first occasion of its practical application. Further reference to these charts will be made later.

Radio bulletins were issued on the evening of the 4th and the morning of the 5th from Chicago, Detroit, Schenectady, and Washington for the benefit of those balloons that were equipped with receiving sets. Only four of the balloonists availed themselves of this source of information, the winner being one of these.

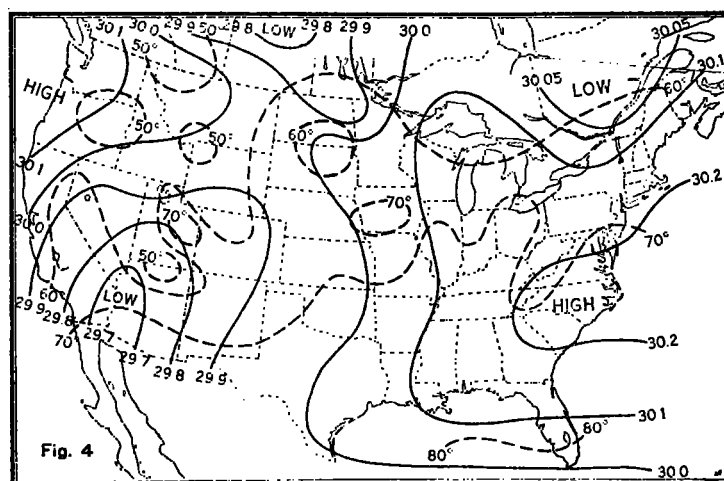
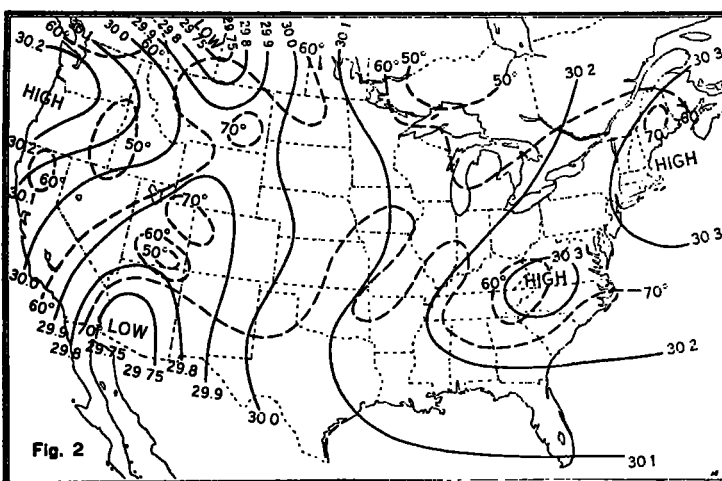
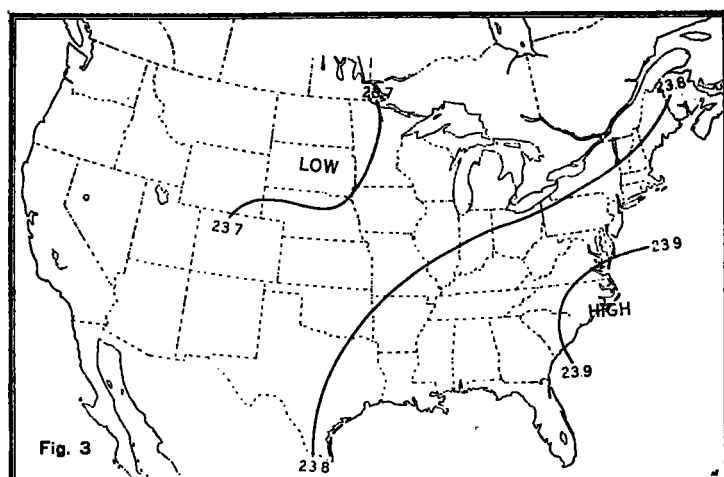
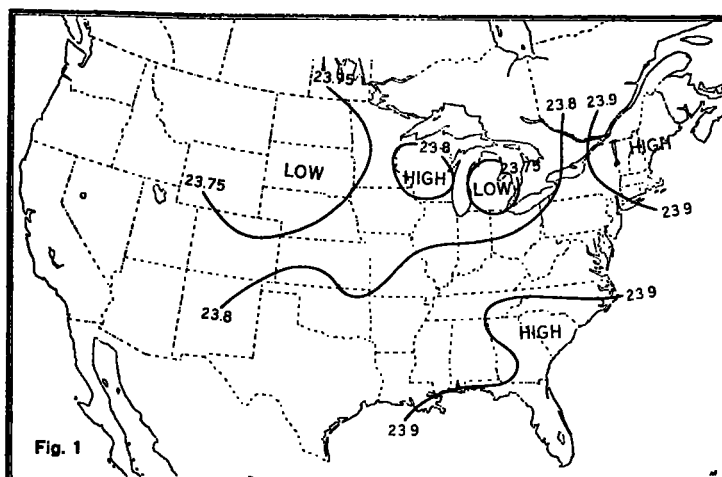
It seems proper, first, to describe the dominant features of the controlling pressure areas a few days previous to the race. The weather over Indiana on the morning of July 1 was anticyclonic, the result of a high-pressure area centered over New England which was becoming merged with the permanent high over the Atlantic and accompanied by relatively low pressure north of the Canadian border. This high over New England had previously crossed the United States with a rate of movement greater than normal. On the next day the Atlantic high continued in control causing moderate to fresh southwest winds above 1,000 meters. By the morning of the 3d there was evidence of a condition approaching stagnation, typical of the summer season, while thunderstorms were becoming general over the Lake region.

A distinct feature of the free-air conditions at this time and one gratefully welcomed by the balloonists was the continuation of moderate westerly winds at altitudes of 1,000 meters and higher, a result, undoubtedly, of the relatively lower temperatures over the Hudson Bay region. An interesting incident of the race indicating the steadiness with which the general wind drift continued was the sighting of four other balloons by Lieutenant Lawrence very close to his own after more than 12 hours in the air. After 23 hours he again sighted one of the

¹ Meisinger, C. Le Roy: MO. WEATHER REV. SUPP. NO. 21. The preparation and significance of free-air pressure maps for the central and eastern United States.

other balloons about 10 miles distant. On the 3d there was apparent on the 2,000-meter pressure chart, Figure 1, a shallow depression over the lower Lakes region. A depression was subsequently found over Ontario on the surface weather map of the 4th, Figure 4. The free-air pressure charts, while being an entirely new feature in this work, were found most helpful and profitable. They conveyed graphically, in a striking manner, the general pressure gradients at these critical altitudes. It is

considerable difficulty resulted in maintaining constant altitudes. A tragic casualty marred this year's race in the death of the two naval officers, Lieut. L. J. Roth, pilot, and Lieut. T. B. Null, aid. Both were drowned in Lake Erie after a forced landing caused by a defective valve. Numerous other less serious accidents occurred to several of the other contestants, due mostly to thunderstorms and in some instances to mechanical defects. Some of the more thrilling escapes from accidents in



FIGS. 1-4.—Pressure maps at sea level, and 2,000 meters above sea level, at 8 a. m., seventy-fifth meridian time, July 3 and 4, 1923. At left, July 3; at right, July 4. Surface maps, below; free-air maps, above.

thought that these charts should be made a permanent part of the meteorological contribution in all future events of this character.

Intermittent showers set in at Indianapolis during the afternoon of the 3d and continued until nearly noon of the 4th. This made inflation somewhat unpleasant, but fortunately no gusty winds occurred, thereby allowing this process to proceed without any serious mishaps.

The balloons took off beneath an overcast sky and drifted north-northeastward in a very light wind, remaining low until they were lost to view of the spectators at the field. Practically all of the balloons encountered thunderstorms during their voyage and owing to these they were finally forced to land. Lieutenant Lawrence observed a temperature lapse rate at an altitude of 3,000 feet, which exceeded the adiabatic rate for dry air, indicating the favorable conditions for thunderstorm development. Strong ascending and descending currents were frequently experienced by all the contestants and

forced landings are briefly described in the following accounts. The first refers to Upson and Andrus.

Balloon split at 5,800 feet, forcing us to descend, using balloon as a parachute.

The following report came from Donaldson:

Landed 6.12 a. m. July 5, 8 miles northeast of Bryan, Ohio; impossible to rip, was compelled to jump, allowing balloon to escape.

The following was taken from the log of Van Orman:

Balloon seemed to be leaking badly, and after sunset it was evident we would soon run out of ballast. All disposable equipment was thrown over and one-half bag ballast saved for landing, which was made in absolute darkness with drag rope. Landing made with help of farmer who pulled balloon out of trees.

Norfleet reported as follows, after being compelled to descend to a low altitude, owing to thunderstorms:

* * * In dragging across a large oak tree the drag rope became wound around a limb two or three times. I was about to cut it away when I attracted the attention of some people and asked them to release it or cut it at the tree. They were proceeding to do this when a

gust of wind of about 25 miles an hour struck the balloon forcing it down into another tree, at which time the rip cord became entangled in the branches of this tree, pulling it loose from the basket. This forced me to land at once and ended the race so far as this balloon was concerned.

The following is taken from McCullough's log:

Forced to ground by being caught in two thunderstorms while over Coraopolis, Pa., one from the northeast and one from the southeast. Terrific winds which drove the balloon almost due west and requiring a rip landing at Frankfurt Springs, Pa.

Some of the meteorological conditions encountered by Lieutenant Lawrence's balloon were described by Lieutenant Reicnelderfer aid, as follows:

July 5, 11.20 a. m. Altitude, 13,400 feet. Temperature, 45° F. Cu. rising to the west, north, and east. Mist is forming on a level some hundred feet below the balloon. Our course is east. Humidity is high enough to condense breath. A rainbow appeared on the mist around the balloon shadow.

2.30 p. m. Altitude, 14,500 feet. Course east. Cu. Nb. closing in to the north, east, and south.

2.35 p. m. Altitude, 14,300 feet. Below us at about 9,000 feet is a thick Cumulus mist. Sky: 5/10 Cu. and 4/10 Cu. Nb. Thunderstorms in all directions.

4.05 p. m. Passing through Cu. We are valving almost continuously. Balloon rising at rate of 600 to 800 feet per minute. We are in a rising current and our gas is expanding rapidly because of higher temperature. The balloon is rising rapidly through the edge of the Cu. Nb. and is passing through the cloud very rapidly.

4.10 p. m. Emerged from² top of Cu. at about 14,000 feet. We were valving almost continuously. The sun was shining brightly. Balloon rose rapidly to 16,500 feet. We held this altitude for several minutes. Towering Cu. all around us. Some below us. Cu. Nb. were on all sides and growing rapidly. We valved for a minute or two. Balloon rose to 17,000 feet. Statoscope gave indication that we were about to descend. Valved more. Balloon rose 200 feet higher. Valved continuously for three or four minutes, both hanging to valve cord. Balloon descended 100 or 200 feet. Stopped valving. Ascent began again. Valved one or two minutes. Rose to 17,600 feet. Continued valving. Rose 200 feet higher, where the balloon remained for a short time. Valved one or two minutes. Rose to 18,000 feet. The Cu. Nb. were growing all around us and thunder was frequent. Other Cu. tops were 2,000 or 3,000 feet below us. Valved several times for one or two minute periods. The statoscope at times indicated descent. This never continued for more than 50 or 75 feet, when ascent began again. Rose by degrees to 18,500 feet. We remained between 18,500 and 18,000 feet for 30 minutes or more. The flotation

² The nearly continuous valving as recited in this paragraph seems to be conclusive evidence that the balloon was in a strong ascending current in which the air was rising en masse rather than in discontinuous shreds as has sometimes been suggested.—EDITOR.

bags burst one after another with loud reports. We valved for two or three minute periods (as long as the two of us could hang on to the valve cord) six to ten times. Cu. tops were all around us. There was frequent thunder. There were some Cu. tops below us some 3,000 or 4,000 feet. Finally, after many minutes of valving, descent began slowly. Reached top of clouds at about 14,000 feet. Descended rapidly through clouds for several thousand feet at rate of 1,000 or 1,200 feet per minute. Began expending ballast including the helium bottle. Came out of base of clouds at about 7,000 feet. Mountains were all around, a town or two, and a railroad. There were occasional cleared fields and a great deal of woodland. Descended rapidly to 500 feet. Dumped over ballast as balloon neared ground. Drag rope touched as balloon descended to within a few feet of the trees. The drag rope caught in the trees. We looked for a landing place. The surface wind was light westerly (?) We finally loosened the drag rope and headed for a small field. Farmers were gathering. We called to them to hold us. We landed easily at 5.55 p. m. with two bags of ballast. A shower began just before we landed. We valved down, then ripped.

The table below gives the names of pilots and aids, the distance traversed, and time in the air of each contestant. The list is arranged in the order of the distance covered.

Pilot.	Aid	Landed (nearest town).	Distance.	Time in air.
(1) Lieut. R. S. Olmstead, U. S. Army.	Lieut. J. W. Shop-taw, U. S. Army.	Marilla, N. Y.	Miles. 449.5	H. m. 28 15
(2) Lieut. J. B. Lawrence, U. S. Navy.	Lieut. F. W. Reichelderfer, U. S. Navy.	Glen Campbell, Pa.	398.1	25 42
(3) H. E. Honeywell, civilian.	P. J. McCullough, civilian.	Brockton, N. Y. ...	397.2	28 11
(4) Capt. L. T. Miller, U. S. Army.	Lieut. C. M. Brown, U. S. Army.	Ford City, Pa.	370.0	23 31
(5) Capt. C. E. McCullough, Officers' Reserve Corps.	Lieut. C. R. Bond, U. S. Army.	Frankfurt Springs, Pa.	312	20 4
(6) Lieut. F. B. Culbert, U. S. Navy.	Lieut. T. D. Guinn, U. S. Navy.	Alliance, Ohio.	294	20 6
(7) Lieut. J. B. Jordan, U. S. Army.	Lieut. M. F. Moyer, U. S. Army.	Macedonia, Ohio. .	272	(?)
(8) Lieut. Commander J. P. Norfleet, U. S. Navy.	Lieut. J. B. Anderson, U. S. Navy.	Mount Eaton, Ohio.	250	18 28
(9) J. A. Boettner, civilian.	J. M. Yoltan, civilian.	Fremont, Ohio.	199	16 10
(10) R. F. Donaldson, civilian.	P. A. Erlach, civilian.	Bryan, Ohio.	157	(?)
(11) R. H. Upson, civilian.	C. G. Andrus, Weather Bureau.	Wapakoneta, Ohio	118	(?)
(12) W. T. Van Orman, civilian.	H. V. Thadden, civilian.	Hartford City, Ind.	68	5 40
(13) Warren Rasor, civilian.	Lieut. R. Emerson, U. S. Naval Reserve Force.	Atlanta, Ind.	30	2 50

LIGHTNING FATALITY.

By ERIC R. MILLER, Meteorologist.

[Weather Bureau Office, Madison, Wis., June 27, 1923.]

On Monday, June 18, 1923, two instructors in the University of Wisconsin, W. E. Armentrout and M. L. MacQueen, were struck by lightning while crossing an open lot used by the university for the storage of coal. Armentrout was instantly killed, but MacQueen is now recovering, and I have obtained the following information from him:

He was conscious throughout the period of the electrical discharge and realized that he was being struck by lightning. He says that the pain of the spasmodic contractions of his muscles was terrible, but the noise and heat of the flash were nearly as bad. He speaks also of a sensation of terrible pressure on his head.

The current entered his body at his left shoulder, which is seared over an area of about 4 inches. The muscles of his legs near the ankles were wrenched by the spasmodic contractions and were swelled so that his leg at that point was about twice the normal size when I saw him. He was paralyzed from the waist down for a few hours after the flash.

Armentrout, who was killed, was also burned on his left shoulder and arm, and a small patch of hair was burned from his head. MacQueen, who fell beside Armentrout, says that he tried to rouse Armentrout and noticed that as he did so Armentrout turned blue. Doctors tell me that this cyanosis indicated that Armentrout's heart had stopped, probably as a result of severe tetanus due to the passage of electricity through the muscle of the heart.

The place where these men was struck is a very low place, and ground water is not far below the surface. Three holes remain to show where the lightning entered the ground. That iron has little directive effect on lightning is shown by the fact that a railroad rail lay about 10 feet away, the track of a railway switch about 30 feet away, a crane 100 feet away, and wire fences and the buildings of the Forest Products Laboratory about 150 feet away. The cloud, which came from the southwest, had passed over houses, trees, and an iron smokestack within a few hundred yards.